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THE GREAT DEVELOPMENTS AND ACHIEVEMENTS IN GEOPHYSICAL PROSPECTING TECHNIQUES IN CHINA DURING THE PAST DECADE

- COMMUNIST CHINA -

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THE GREAT DEVELOPMENTS AND ACHIEVEMENTS IN GEOPHYSICAL PROSPECTING TECHNIQUES IN CHINA DURING THE PAST DECADE

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Whether it be in the scope of activities, the rise of the technological level or the increase in actual prospecting effectiveness, the development of geophysical work in China has been unusually rapid during the past decade. The revival by the socialist regime of New China of a scientific technique almost forgotten by Old China amply demonstrates the party's and government's interest in and support of scientific technology.

Geophysical prospecting represents a new phase in techniques of geological prospecting in the sense that physical science is utilized to help locate ore deposits and geological features hidden from view; without this approach the amount of minerals that could be discovered by mankind would be very limited. Hence, the importance of geophysical prospecting.

Under the reactionary regime of Old China, the development of prospecting was neglected. During this long period, sporadic work of little consequence was done in the field of petroleum prospecting, geological surveying and physical research. The scope was narrow and the technique backward. There was useful geological prospecting. After the liberation, the political factors that hindered growth in this area were removed. The newly developed geological scientific technique was supported by the party and government with vigor and firmness. However, for a long time people questioned the effectiveness of geophysical prospecting, believing that apart from oil prospecting, the problem of general ore prospecting would remain unsolved, especially with reference to the location of metallic ores involving an appraisal of com-

plicated geological conditions and a clear understanding of the physical properties of the ores under examination. The future was not considered bright. Thus it was believed that theoretical research should be reinforced instead. This general attitude tended to retard the prospecting line of thinking.

Nevertheless, with the party and the government firmly determined to support newly developed enterprises, with a superior social environment, with the extension of practical geophysical prospecting work in China and with the absorption of advanced experiences from the Soviet Union and other sister states and the summarization of our own experiences in field work to raise gradually our operating level, important prospecting achievements were made in the interests of national economic construction. Further growth in geophysical prospecting techniques was noted in the course of the comprehensive people's great leap forward in 1958. Facts proved that suspicions about geophysical prospecting techniques were unfounded and was now basically nonexistent in men's minds. At present, the problem is not suspicions about the efficacy of geophysical prospecting but rather its multifarious application to geological prospecting work. It is understood that geophysical prospecting constitutes a step forward in the pursuit of geological science.

This article will discuss the rapid rise in the level of geophysical prospecting techniques in China and the rich harvest of ore prospecting.

I. Rapid Development in Techniques

(1) Rise in technological methods employed and in the variety of ores prospected -- The state of geophysical prospecting techniques handed down from Old China was extremely backward; equipment was simple and there was little variety to speak of. In some areas, gravitational methods were employed for oil prospecting and magnetic surveys were undertaken; for individual drilling, oil wells were power-surveyed. The metallic ore situation was even more deplorable. Where manpower and equipment permitted, limited, simple and easily operated devices, such as magnetic, torsion, electric resistance and natural electric current appliances, were used. One or two sets of such appliances were made available for use by limited personnel throughout the country. The volume of work done was small.

During the first few years after the liberation,

in addition to an increase in prospecting personnel and the equipment used in magnetic, gravitational and torsional methods -- five or six types in all, the seismological method, which had never before been used, was immediately added to the list. For petroleum prospecting, it is essentially a geophysical method, which was not used in the past because of the complicated equipment required. Now that the technique is generally under control, the method is being extensively employed for oil prospecting, and it will be used for coal field surveying. For area survey work, an aeromagnetic method was employed after the liberation. That which was thought of as inconceivable in the past has been placed under perfect control with the aid of the Soviet Union. Area surveying across the country has been completed. Not only are changes in the magnetic field recorded but also changes in the intensity of radiation are placed on record by means of the aerial radiational surveying method.

For general metallic ore prospecting, various types of geochemical prospecting methods (still a part of the geophysical method), such as surface rock, clay metallurgical surveying, analysis of surface and underground water metallic content and search for blind mineral ore deposit by the hydrolytic method, have been developed. Furthermore, surface (aerial) and oil-well radiational surveying methods have been employed. Prospecting by electric devices are used to ascertain geological structure. Where metallic ores exist, several types of cross-section electric resistance methods are used to determine the nature of mineral layers. Isoelectric lines are employed to ascertain the quality of conductible mineral sulfides and to determine their latent limits by a charging device. Induced current may be utilized to detect metallic ore deposits. Alternating currents of various frequencies are caused to pass through the deposits to activate the induced current in order to measure the amplitude and phase of the magnetic field. In a tunnel, a radio wave method may be employed to detect latent ore deposits. A method by which the electrochemical activity of metallic minerals, when stimulated by a more powerful electric current, may be utilized to bring on a polarization effect for the production of an electric shock has been developed.

Electric surveying within the oil well, not longer confined to simple electric resistance and natural electric current methods, has been aided by the addition of many new techniques, among them electric shock, electro-

de and electric potential methods. Coal fields and petroleum deposits are now prospected by radiational "chia-ma"; "chia-ma" radiation and neutrons are employed for coal pit or oil well prospecting. The principle of nuclear reaction is applied to prospecting for the development of new methods.

All in all, geophysical prospecting techniques now under control are far more numerous compared with those in use during the early liberation period, and are incomparable in terms of the pre-liberation record. China is already well provided with such methods as are being used abroad. New methods being tested abroad are also being actively examined by Chinese scientists.

Geophysical prospecting techniques were formerly regarded as applicable only to petroleum and magnetite. They were unsuccessful when applied to the prospecting of other mineral ores, especially non-ferrous deposits. During the past decade, prospecting techniques previously valid only for oil and magnetite now are used for coal, copper for lead, zinc, chromium, nickel, tin, wolfram, aluminum, pyrite, graphite, etc. because of geophysical prospecting techniques made possible by the absorption of practical experiences from the Soviet Union. Direct and indirect prospecting results were achieved. By utilizing geophysical methods, we have embarked upon the prospecting of rare dispersion elements. Radioactive minerals are being prospected by aerial, surface and intrawell radioactive methods with apparent success.

Not only is geophysical prospecting not confined to the search for mineral ore but also it is adapted to geological surveying by area (such as aerial magnetic surveying, metal content surveying and radioactive surveying) in order to supplement surface geological observation and to ascertain geological conditions beyond the covering layer. Also, it is employed to locate underground water in connection with engineering sites for capital construction and to determine the structural nature of underground foundation rocks.

The application of geophysical methods to prospecting has expanded in no small degree in China during the past decade, and it has taken roots.

(2) Correct use of various methods and their improvement in field work -- Owing to limited operation, error and lack of experience at first, the practice of geophysical prospecting was not as satisfactory as anticipated. These drawbacks were particularly serious in the metal mining area. Since the

liberation, the operational results from various methods have been disseminated across the country on a large scale, giving people a basis for broader and more systematic observation. Coupled with Soviet experience, various methods are now basically under control insofar as rules for their application collectively as well as individually are concerned. Thus, geophysical prospecting efficiency gradually has increased.

Geological conditions under which ore deposits may exist are extremely complex, changing as conditions change. Environmental and physical factors may influence the formation of ore deposits, which will differ in different areas even if the ore in question is the same. Field methods should, therefore, change when conditions existing either in the mine or in the area are different, they must be quickly adjusted, tested while production is proceeding and continually revised if necessary. Not only should geological evidence be closely correlated, but multiple methods (except where a single method is employed on individual merit) should also be supplementary and complementary. To think that physical evidence may be solely depended upon or that a single method may be used for ore prospecting is no longer acceptable. On the basis of extensive practical work over many years, it may be said that field work in geophysical prospecting is under control and that much progress has been made since the early liberation days.

Geophysical ore prospecting should be undertaken mainly for the achievement of general regional prospecting objective (especially in areas where metal mines exist). No adequate result is possible if prospecting work is confined to the mining area. This important experience was obtained from the Soviet Union, and its accuracy has already been verified by the results of our own practices. Geophysical prospecting activities, concentrated on mining areas in the early days of the liberation, were shifted toward the periphery for broader area prospecting work and more coordinated regional geological surveying work. In the mining area such effective activities as the use of electric current and charging methods were retained. This important change (reference: Journal of Science, No 11, 1954, page 1) marked a step forward in the development of geophysical prospecting techniques.

During the past decade, there was enormous development in geological drilling and prospecting and large-scale engineering construction in mountainous

regions, and extremely rich geological data was gathered. This valuable factual evidence proved the validity of the geophysical signs which had been observed. Geophysical sygns that were built on geological hypothesis in the past could not be verified, and it was difficult to draw any useful experience from such hypotheses. Now that we are provided with substantiation, our capacity to interpret physical signs will apparently rise to a higher level.

(3) Incessant substantiation of new techniques -- On the one hand, we should accumulate experience from practical work in order to extend the results of the geophysical method of ore prospecting and, on the other hand, various techniques of proved advantage should be adopted. Older types of equipment should be improved upon, and research on the creation of new equipment should be conducted.

Meantime, scientific research units in China are engaged in developing new techniques for geophysical ore prospecting according to a plan formulated for national scientific development. For example, electronic techniques; magnetic belt recording techniques and supersonic wave techniques are being utilized to improve equipment for ore prospecting by the seismological method. As to the gravitational prospecting method, the emphasis of research lies in increasing the precision and portability of gravitational equipment. Preparation is under way for the development of prospecting by the aerial electric current method. The principle of nuclear reaction is being employed in the search for rare, dispersion element ore deposits. Some methods are being tested in field production. For example, an electric shock method is being tried in metal mining.

II. Great Ore Prospecting Achievements

By applying the geophysical method to ore prospecting throughout the country during the past decade, great accomplishments have been made in the field of ore prospecting and geological study. The analysis follows:

(1) General prospecting of petroleum, natural gas and coal -- In regional prospecting for oil, natural gas and coal deposits, the geophysical method was used in the sedimentary basins, plains and deserts of China to ascertain their geologic structure in depth. Concrete structures possibly containing oil deposits had been marked out as a preliminary step. The depth of the

sedimentary rock layers and their distribution in the basins were examined to determine locations for oil, natural gas and coal deposit prospecting. For the conduct of this geophysical work, aerial and magnetic methods were principally employed, supplemented by the gravitational method for depth prospecting and the electric and seismological methods for line and cross-section prospecting in the basins and plains. Fro example, regional surveys of this nature were conducted at the Chun-k'o-erh basin in northwest Sinkiang Province, the Ch'ai-ta-mu and Chiu-ch'uan basins in Ch'inghai Province, Szechwan Basin, the Sung-hua-chiang=Liao-ning plains of northeast China and the great plains of northeast and east China. Significant geologic clues were acquired for further ore prospecting work.

In prospecting the geologic structure of oil deposits by the seismological method, much work was done in the oil fields of the Chiu-ch'uan basin, the K'e-la-ma-i of Sinkiang Province, and the Ch'ai-ta-mu and Szechwan oil deposits, contributing in an important manner to the rational development and drilling of oil wells.

In areas such as the great plains of north and east China and Sung-hua-chiang=Liao-ning and O-erh-t'u-ssu, where oil deposits had not been ascertained and where a search for oil-containing structures was in progress, important prospecting work by the seismological method was completed, giving important indications for preliminary drilling.

Geophysical prospecting methods for oil-well drilling were being generally employed in combined prospecting for oil, natural gas, etc. These measurements were calculated to ascertain the porosity and saturation points of the corresponding layers in the oil wells.

Research on the geologic structure of coal fields in China is at the moment confined to prospecting by the electric method to determine the depth, thickness and fracture of coal seams. Work is progressing at many coal fields with a view to solving the difficult problem of the geologic structure of the coal bed. The geophysical prospecting method was used with apparent success in coal-pit drilling work to determine accurately the depth of the coal bed and the skipped sites of corresponding seams. Recent coal-pit drilling was conducted mostly on the basis on these data. The rate of labor productivity will be greatly enhanced if drill-

ing can be centered only at the heart of the deposit in some localities.

(2) General prospecting of iron ore -- The most direct and effective way to prospect latent and highly-magnetic magnetite is considered to be by the aerial and surface magnetic method. Many magnetite fields were thus discovered. In the early days of the liberation, the work was concentrated on the construction bases of principal iron and steel enterprises, such as Anshan, Pai-yun-o-po of Pao-t'ou and Ta-yeh mine of Wu-ch'ang and Hankow. Latent ore deposits were thus discovered and the scope of the mining districts was also enlarged. For example, latent ore deposits were struck at Chien-lin Shan after the mining district of Ta-yeh had been prospected by the surface magnetic method.

Many iron ore deposits were subsequently found in China, supplying vast amounts of mineral resources for use by the large, medium and small-size iron and steel works operating in the country. Especially in 1958, when the industrial and agricultural great leap forward was in full swing, the discovery of iron ore by the magentic prospecting method coincided with the enormous mass movement for the establishment of iron and steel works.

(3) General prospecting of copper, lead, zinc, nickel, chromium and other metal ores -- Copper ore assumes several types in its natural formation. Copper-containing magnetite (silica rock formation) was prospected by the geophysical method with apparent success in China. These types are broadly distributed through-out China. Latent magnetite in copper seams of medium and small size, discovered in northeast China mainly by using the surface magnetic prospecting method, contributed in a significant way to the growth of the copper smelting industry there. New deposits were also found in Anhwei Province by the geophysical method, which was employed with equal success in other copper producing areas of China. Copper-containing pyrite was prospected with good results by a combination electric method.

Lead and zinc mines are very widely scattered throughout China. Using the geophysical prospecting method, work was satisfactorily tested at many mines while production was in progress. An ore deposit containing lead and molybdenum was discovered when a method for analyzing the metallic content of surface clay was employed for the first time with good result. Important latent ore deposits were brought to light in Tsinghai Province

by using an electric prospecting method (combination cross-section method). In other areas, surface natural electric current, magnetic and surface clay metallic analytic methods were used in combination for prospecting many multi-metallic ore deposits.

As for chromium, in the past four or five years, vast areas of overlapping rock were successfully marked out by use of aerial magnetic and surface magnetic methods. Chromium was usually found in these rock formations. After the geologic survey, activities in the area designated were expanded, increasing the scope for prospecting. Geophysical and geological activities will be synchronized for direct prospecting of chromium ore deposits. Prospecting completed in mountainous regions helped locate ore deposits indirectly. For example, by utilizing the surface magnetic prospecting method, it was possible to differentiate rock layers containing ore from those that did not. This knowledge of ore distribution served as a guide in excavation work aimed at the location of deposits.

While little was done in the past in locating nickel ore deposits by the geophysical method, testing work, coupled with production, was carried on recently in many areas to meet the urgent demand for nickel for national industrial construction. In these areas, nickel and copper ore deposits seemed to have co-existed in the form of sulfides such as copper sulfide, etc., and were closely associated with overlapping and basic igneous rocks. Geophysical measurement was mainly concerned with the analysis of sample clay and rocks by the magnetic method in order to determine their copper and nickel content. These rocks, generally covered by surface earth, were first marked out for examination, serving as mother ores in which nickel was to be found. Such nickel ore deposits are to be found in southwest and northeast China. This important procedure had to be completed before any geologic prospecting was done. Individual cases showed that nickel ore deposits could be directly prospected by the natural electric current method. Combined geophysical methods were being tested recently to determine the production potential of pedestal rocks and to ascertain the location of ore deposits in the rock.

Tin, wolfram, aluminum and rare, dispersion element ore deposits: For these ores, prospecting by geophysical methods is still in its formative stage. Some work experiences were acquired, although results from prospecting were of little importance. Sandstone tin ore

deposits were discovered when surface earth from Ko-chiu, Yunnan Province, was tested for its tin content. White wolfram ore deposits containing magnetite (silica rock formation) as found in Yunnan and Kiangsi provinces were successfully located by the magnetic method of prospecting. In the lower portion of weathered limestone rock covered by loess in Shensi Province were observed deposits containing uranium and thorium as prospected by aerial, surface and intrawell radiational methods were mixed some rare elements such as niobium, tantalum and cerium. These rare elements were also observed in many multi-metal ore deposits.

(4) General prospecting of nonmetallic ores -- Prospecting of non-metallic ores by geophysical methods are at the moment only applied to pyrite (raw material for sulfur extraction) and graphite. Geophysical methods are comparatively speaking effective in the search for latent pyrite. In recent years this work was begun in the mineral area of Anhwei Province. By the geophysical method, the natural electric current was found to be heavily loaded with a magnet of high conductivity, indicating that these conditions had been brought about by the industrially valued pyrite. New signs were observed in a mineral area in Kwangtung Province after it had been prospected for more than two years. New ore deposits were located elsewhere in China under similar circumstances.

The prospecting of graphite ore deposits by geophysical methods was being tested individually, and natural electric current signs were observed. After test drilling and prospecting by electric current, the location of graphite deposits in several areas was verified.

Facts given above definitely show that prospecting by geophysical methods has made enormous progress since the liberation and that it has assumed an important role in the nation's geologic survey enterprise. It has also contributed to the discovery of petroleum, natural gas, coal, metal ore deposits and rare dispersion metallic ores.

Geophysical prospecting techniques are expected to meet increasing demands from geologic survey work for more direct ways of prospecting. For example, direct prospecting for oil resources calls for search at deep levels, and rare dispersion elements can be prospected directly only in a concentrated area. To satisfy these demands, scientific achievements, especial-

ly geophysical and technological accomplishments, should be utilized and followed up with research.

In China are hidden many distinct ore deposits. This distinction is brought about by the topographic and grologic environment found in China. In view of these characteristics that are distinctly Chinese, it is worthy of note that geophysical prospecting techniques in China should be so coordinated.

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